Chapter 3
REFORMULATED FUELS AND RELATED ISSUES

INTRODUCTION

Reformulated gasoline (RFG) is a cleaner burning fuel than conventional gasoline that will significantly improve air quality by reducing emissions from all gasoline-burning motor vehicles and engines. RFG is required by the federal Clean Air Act Amendments and California Air Resources Board (CARB) regulations, and is considered a cost effective method to help achieve state and national air quality standards.

This chapter includes a summary of the federal and state regulations that brought about RFG. The chapter also includes a description of CARB's Phase 2 Reformulated Gasoline Advisory Committee and its subcommittees, and the recent transition to Environmental Protection Agency (EPA) Phase 1 RFG in California and the nation. Current CARB RFG issues such as fuel supply and demand, transportation and distribution, and potential marketing concerns are also summarized.

CLEAN AIR REGULATIONS

To help meet new clean air standards, both the federal and state governments have enacted legislation which mandates a change in the composition of gasoline to reduce motor vehicle emissions. Following is a timeline for the implementation of the new gasoline standards:

November 1, 1992: Implementation of CARB Phase 1 gasoline.

January 1, 1995: Federal RFG (EPA Phase 1) began to be sold at the retail level in the nine areas in the nation with the greatest ozone pollution and additional areas around the country which have voluntarily opted in to this program. Los Angeles and San Diego are the two mandated regions in California.

January 1, 1996: Leaded gasoline phased out on a national level.

March 1, 1996: CARB Phase 2 RFG required at the refinery level.

April 15, 1996: CARB Phase 2 RFG required at the terminal level.

June 1, 1996: CARB Phase 2 RFG required at the retail level for the entire state. Replaces the use of EPA RFG in California.

January 1, 1998: EPA RFG moves from the Simple Model, which tracks five fuel parameters, to the Complex Model, which tracks three additional fuel parameters. The temporary exemption from four CARB Phase 2 RFG fuel parameters ends for small California refiners.

January 1, 2000: EPA Phase 2 RFG goes into effect in the areas required to use federal Phase 1 RFG.

Federal RFG

The United States EPA required refineries to begin implementing Phase 1 of their RFG program on December 1, 1994, as mandated by the RFG provisions of the federal Clean Air Act Amendments. The use of this gasoline is expected to reduce various pollutants by 15 to 19 percent from 1990 levels. This fuel is required in the nine areas, nationwide, with the worst ozone pollution problem. The Los Angeles Basin and San Diego region are currently the two areas in California where use of EPA gasoline is required. These two regions represent 57 percent of the state's gasoline demand. Sacramento became the tenth area when it was redesignated from severe to serious on June 1, 1995, with program implementation to become effective 12 months later, on June 1, 1996.

Federal law requires reductions in auto emissions of volatile organic compounds (VOCs), a major cause of ozone formation in the summer months, as well as toxic air pollutants. The first stage of EPA Phase 1 RFG requires reduced benzene, lower Reid vapor pressure (RVP) specifications, added oxygenates, and heavy metal limitations.[1] The overall goals of federal RFG are to reduce ozone formation during the summer months and reduce toxic emissions year round.

In January of 1998, the second stage of the federal Phase 1 RFG program will require that refiners move from the Simple Model (five parameters for which compliance is judged) to the Complex Model, which introduces three additional parameters (sulfur, olefins and distillation range limitations). Prior to 1998, refiners have the option to use the Simple or the Complex Model to certify that their fuel meets EPA RFG requirements. Most refiners producing EPA RFG chose to use the Simple Model due to limitations of commingling the two types of formulations. Once the Complex Model option is selected, however, the refiner is not permitted to switch back to the Simple Model option. With these EPA parameters, performance standards are established and refiners are given flexibility as to how to meet the standards. This transition will not significantly affect California, which will already have been under CARB Phase 2 RFG regulations for two years.

Federal Phase 2 RFG will be delivered beginning in December 1, 1999, and will be required at the retail level in all areas outside California using federal Phase 1 RFG, beginning on January 1, 2000. This gasoline is expected to reduce oxides of nitrogen (NOx) by 5.5 percent, toxic air pollutants by 20 percent, and VOC by 27.5 percent. (These figures are calculated based on a 1990 model year vehicle as it would emit in 2000 if there were no Phase 1 program.) Within California, CARB Phase 2 RFG will continue to be required since, under current specifications, EPA Phase 2 RFG does not meet all of CARB's requirements. Specifically, the fuel property specifications for aromatics, olefins, sulfur and the distillation temperatures are higher for EPA Phase 2 than for CARB Phase 2.

California Air Resources Board RFG

Motor vehicles are the largest contributors to California's severe air quality problems, accounting for 50 percent of the emissions of VOCs and NOx (which combine to contribute to the formation of ground level ozone, the main ingredient in smog). CARB Phase 1 RFG, which was implemented in November 1992, set a limit on RVP, required detergent additives to control engine deposits, and completed the phase-out of leaded gasolines in California. According to CARB, the use of Phase 1 RFG was responsible for one-third of the mobile source air quality improvements from various air pollution reduction programs.

When compared to CARB Phase 1 RFG, CARB Phase 2 RFG has a lower RVP, aromatic hydrocarbon content, distillation temperatures, sulfur, and olefins, as well as added oxygenates. It will produce the largest emission reduction at one of the lowest costs per tons of pollution avoided of any of the various control measures employed to date. When compared to CARB Phase 1 gasoline, the use of CARB Phase 2 RFG will reduce emissions of VOCs by 17 percent, NOx by 11 percent and carbon monoxide (CO) by 11 percent. These reduction percentages are for all the onroad gasoline-powered vehicles in use during 1996.

CARB standards are more rigorous than EPA's Phase 2 requirements, setting precise specifications for eight fuel parameters. Significant improvement in air quality is expected and a reduction in emissions of cancer-causing pollutants, translating to an expected 40 percent decrease in the cancer risk due to the use of gasoline-powered motor vehicles.

The resulting cleaner air will reduce breathing difficulties and lung tissue damage, as well as vegetation damage throughout the state. As an additional benefit, 20,000 temporary construction and several hundred permanent jobs were created as a result of these regulations.

CARB PHASE 2 RFG ADVISORY COMMITTEE

CARB formed an RFG Advisory Committee to identify potential problems and recommend solutions regarding the introduction of CARB Phase 2 RFG. The Committee is made up of officials from state energy, automotive, education and environmental agencies, as well representatives from automobile manufacturers, oil refiners and marketers, environmental organizations, and numerous other groups representing the broad interests of the state at large.

The Advisory Committee's purpose is to facilitate the introduction of CARB Phase 2 RFG in California by providing a forum for discussing issues and concerns with all parties affected by the production, distribution, and use of RFG. The Committee's intent is to monitor facility modification progress, examine performance issues and other problems, look at the supply and demand balance, and develop contingencies for potential supply disruptions. To serve the Committee's charge, three subcommittees have been established: Transition, Performance and Public Education.

- **Transition Subcommittee**: The purpose of this subcommittee is to evaluate the petroleum industry's ability to provide CARB Phase 2 RFG to meet the needs of California's motorists and discuss with the Advisory Committee possible measures that can be taken to minimize the impact of potential supply disruptions. This Subcommittee advises the full Advisory Committee, CARB and the Energy Commission on analysis of supply, demand, distribution and compliance information gathered separately by the two agencies. The Transition Subcommittee is also monitoring California's experience with the transition to federal Phase 1 RFG. This transition will prove a limited indicator of the market's flexibility and ability to meet the needs of the state's motorists.

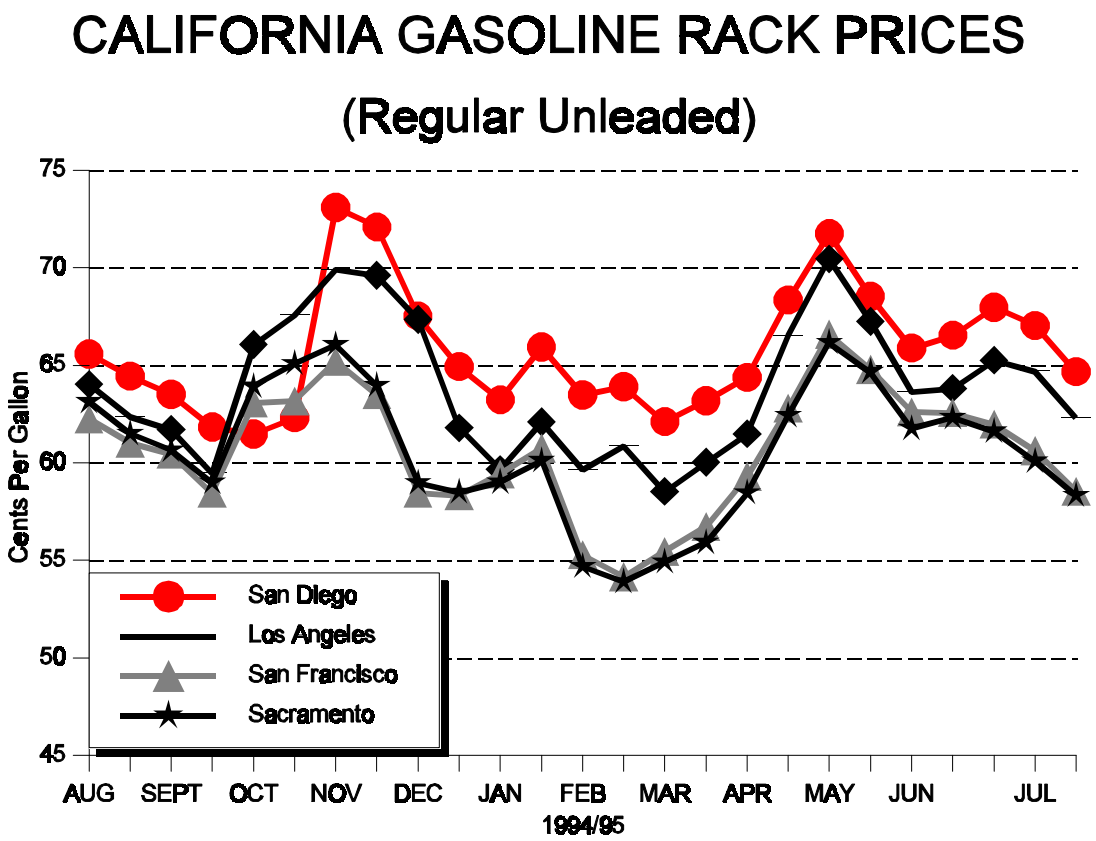
- **Performance Subcommittee**: This Subcommittee's purpose is to inform the Advisory Committee and the CARB on the design of fuel test programs for evaluating the performance of CARB Phase 2 RFG in motor vehicles, fuel storage systems and other equipment. The Performance Subcommittee will facilitate coordination of available resources for the test programs and provide advice regarding potential problems and solutions. This includes addressing performance concerns such as potential materials compatibility problems, additional maintenance, and emission reductions of the new fuel. This is done through on- and off-road test programs, conducted in the laboratory and the field. One such test program is the recent RFG Performance and Compatibility Test Program, which tests CARB Phase 2 RFG in more than 1,000 cars and trucks, as well as boats and utility equipment. The Performance Subcommittee's work also includes vehicle fuel system inspections and data collection on fuel economy.

- **Public Education Subcommittee**: The Public Education Subcommittee advises the full Advisory Committee and CARB on development and implementation of programs to educate industry, businesses, and governmental agencies, as well as the general public, about CARB Phase 2 RFG. Using input from the other Subcommittees, this Subcommittee is addressing the public's potential concerns using various outreach programs and educational resources. The goal of the Public Education Subcommittee is to effectively prepare the motoring public for the introduction of CARB Phase 2 RFG.

TRANSITION TO EPA PHASE 1 RFG

On January 1, 1995, the EPA Phase 1 RFG regulation took effect, requiring the use of less-polluting gasoline in the nine worst air quality areas in the nation, including six southern California counties plus voluntary opt-in areas outside of California. The transition to the new fuel at more than 5,000 service stations in Southern California went smoothly. This can be attributed to an adequate supply of EPA RFG in Southern California and the absence of production problems at the refineries as the result of careful planning by the refiners. Refinery production and inventories were

Figure 3-1



at levels that would be expected for this time period to meet demand. Deliveries to pipeline terminals were available in volumes similar to previous years.

Despite concerns about potential price spikes, the price of EPA RFG was lower than might have been expected to be needed to recover investments for making the new product and cover the cost of oxygenates required for wintertime gasoline. This temporary situation was probably a result of more than adequate supplies of EPA RFG. The wholesale gasoline price differences between Southern California cities (such as San Diego and Los Angeles) and Northern California cities (such as San Francisco and Sacramento) was relatively small before the introduction of EPA RFG. Since that time, this gap has increased, reflecting the additional cost of EPA RFG compared to conventional gasoline (see Figure 3-1).[2] Due to the unavailability of additional segregated storage tanks, Santa Fe Pacific Pipeline Company reduced the number of gasoline grades held in community tanks at the Colton terminal.

The most common complaint regarding the transition to EPA RFG is the administrative burden of the federal reporting requirements placed on the industry, including the difficulty in interpreting some of these requirements and the large volume of paperwork.

CARB PHASE 2 RFG ISSUES

The transition to CARB Phase 2 RFG will set California apart from fuel markets in all other states in the country in terms of fuel specification requirements. To provide this cleaner fuel to the California consumer, refiners have invested more than 4 billion dollars for facility retrofits. The Energy Commission is currently examining issues

about the supply, demand, transportation, distribution and marketing of this California-specific fuel.

CARB Phase 2 RFG Supply and Demand

Energy Commission analysis of confidential data submitted by California refiners indicates that California refiners have the ability to meet a high demand scenario for CARB Phase 2 RFG through the first full year of the regulation, barring any severe unexpected refinery problems. Figure 3-2 illustrates maximum CARB Phase 2 RFG supply capacity compared to a high demand estimate of 2 percent increase per year.[3] The assumed demand change from 1995 to 1996 is actually 4 percent for this time period only, to adjust demand to account for the slightly lower energy content of CARB Phase 2 RFG compared to the various types of gasoline in use during 1995. Although the demand line exceeds the maximum supply volume during 1999, the Energy Commission expects that California refining companies will either import finished CARB RFG from outside California, import additional blendstocks or make additional refinery modifications to expand RFG production capacities by this later date if gasoline demand were to actually grow at the high demand scenario rate.

A Most Likely Demand estimate contrasted with a Best Estimate of supply has also been prepared by the Energy Commission as part of the CARB RFG supply/demand balance. This analysis is based on supply data submitted by the oil companies and demand estimates prepared by the Energy Commission. Figure 3-3 illustrates that the Best Estimate of CARB Phase 2 RFG supply is adequate to meet estimated demand throughout the forecast period.

In addition to producing CARB Phase 2 RFG beginning in March 1996, refineries in California will continue to produce various types of conventional gasolines for export to meet contractual obligations, primarily in Arizona, Nevada and Oregon. California is a net exporter of finished products, transporting these fuels principally by pipeline to Reno, Las Vegas and Phoenix. In addition to pipeline transportation, some product is delivered by truck to Oregon from the Chico pipeline terminal. Figure 3-4 depicts the 1993 flow of gasoline from California.[4] Historically, Southern California refineries produce less gasoline than Southern California consumers use and the export markets in Las Vegas and Phoenix demand. This necessitates movement of refined product from Northern to Southern California by tanker or barge since currently there is no product pipeline connecting the two portions of the state.

Transportation and Distribution Issues

The introduction of CARB Phase 2 RFG in California will affect the transportation and distribution of finished petroleum products within the state. The two principal common carrier transporters of refined products in California are the Santa Fe Pacific Pipeline and CalNev Pipeline Companies. These pipeline companies are both intrastate and interstate carriers, transporting a variety of product grades and specifications.

In order to handle additional fuel grades, the pipeline companies have prepared for increased segregation requirements to avoid losing flexibility and capacity of their system. The pipeline companies have made the investment to construct new storage tanks and also to convert existing tanks to "drain dry" configuration with vapor recovery systems. This conversion increases flexibility by allowing a tank to be emptied completely of one product and filled with another, rather than being dedicated to only one product grade.

The pipeline companies currently transport four basic types of gasoline (leaded and unleaded regular, unleaded midgrade and unleaded premium), each with variations of octane, RVP, oxygenate, bromine, and sulfur content. Since October 1994, the pipelines have also transported Simple Model EPA RFG and RBOB (Reformulated Blendstock for Oxygenate Blending), both in three grades: regular (suboctane for RBOB), midgrade and premium. In addition, the companies transport three grades of diesel: CARB low sulfur/low aromatic, EPA low sulfur, and high sulfur off-highway.

Where there is not enough tankage at terminals to segregate all types and grades for every company, a community tank is used with uniform specifications set by the pipeline company. After March 1996,

Figure 3-2

California Maximum RFG Supply and Demand

High Demand Scenario

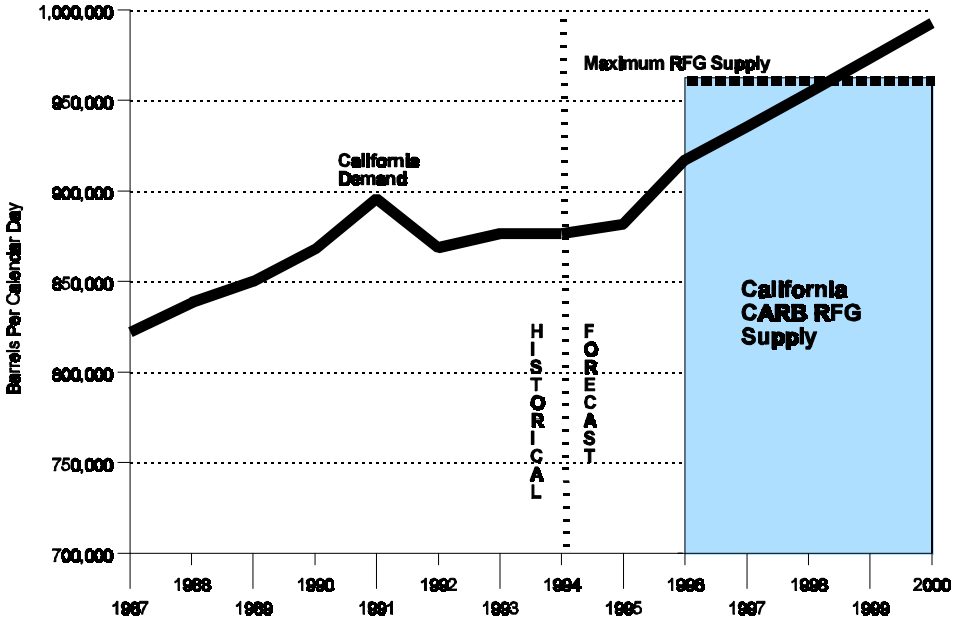


Figure 3-3

California Best Estimate RFG Supply and Demand

Most Likely Demand Scenario

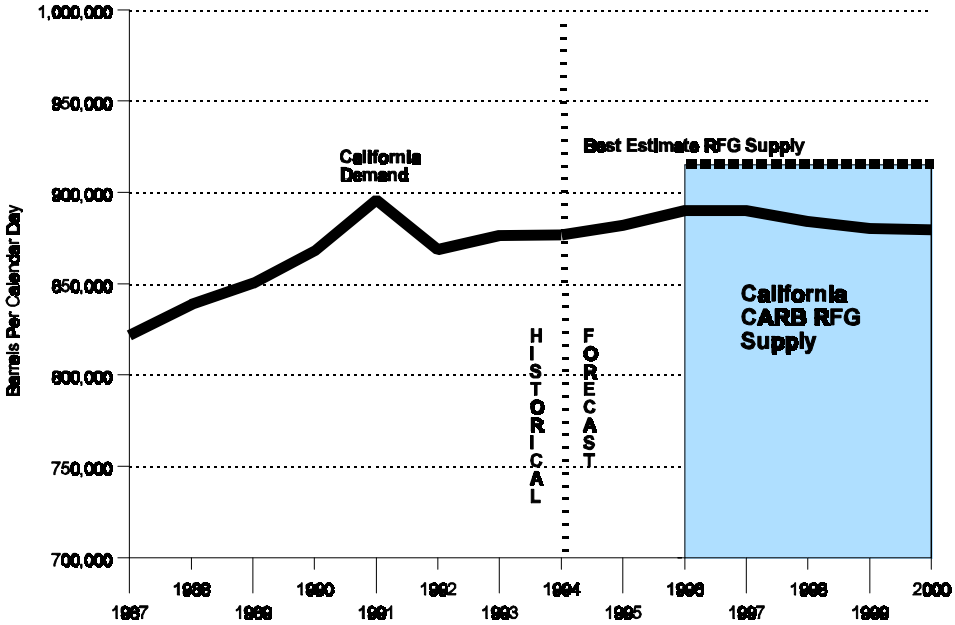
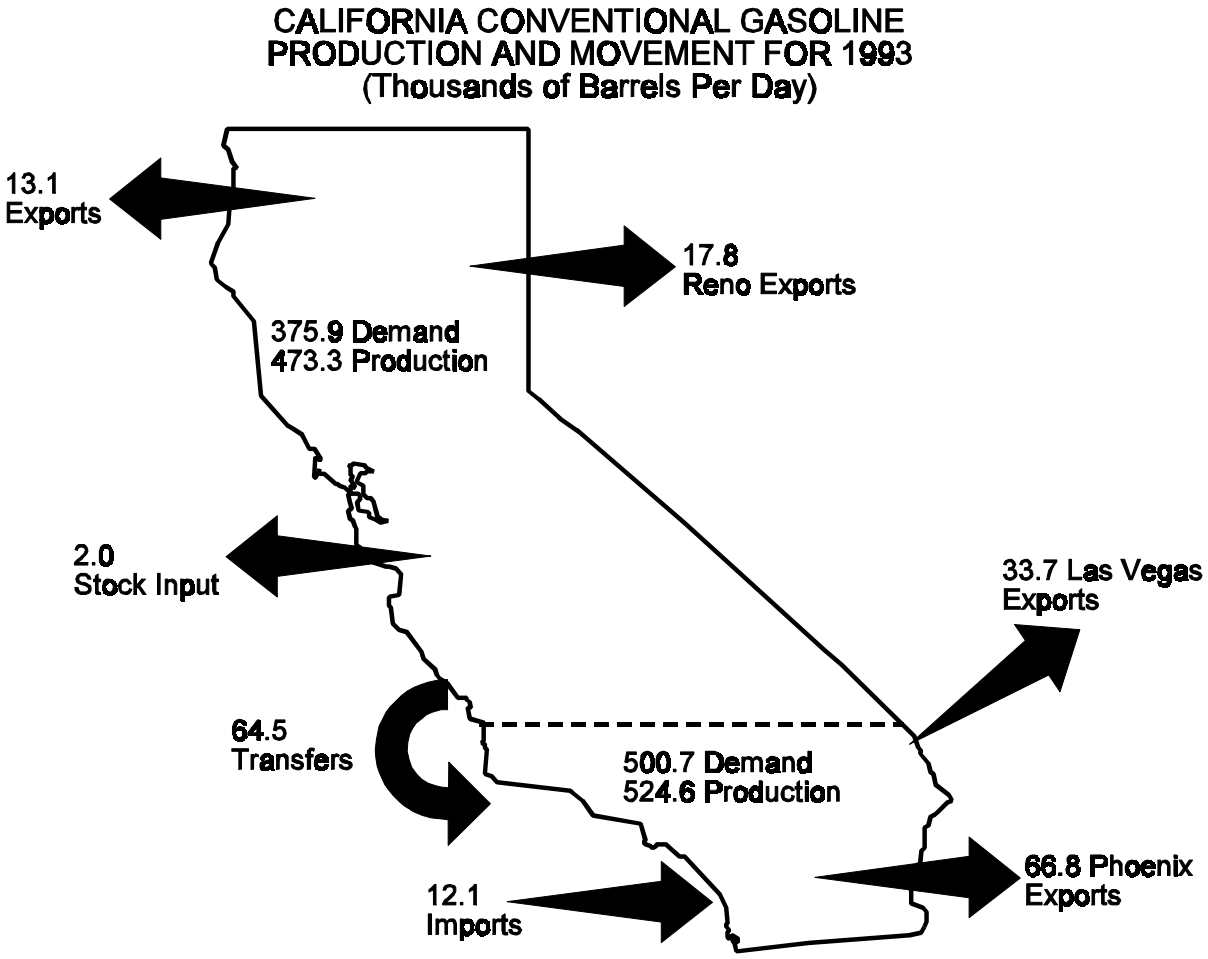


Figure 3-4

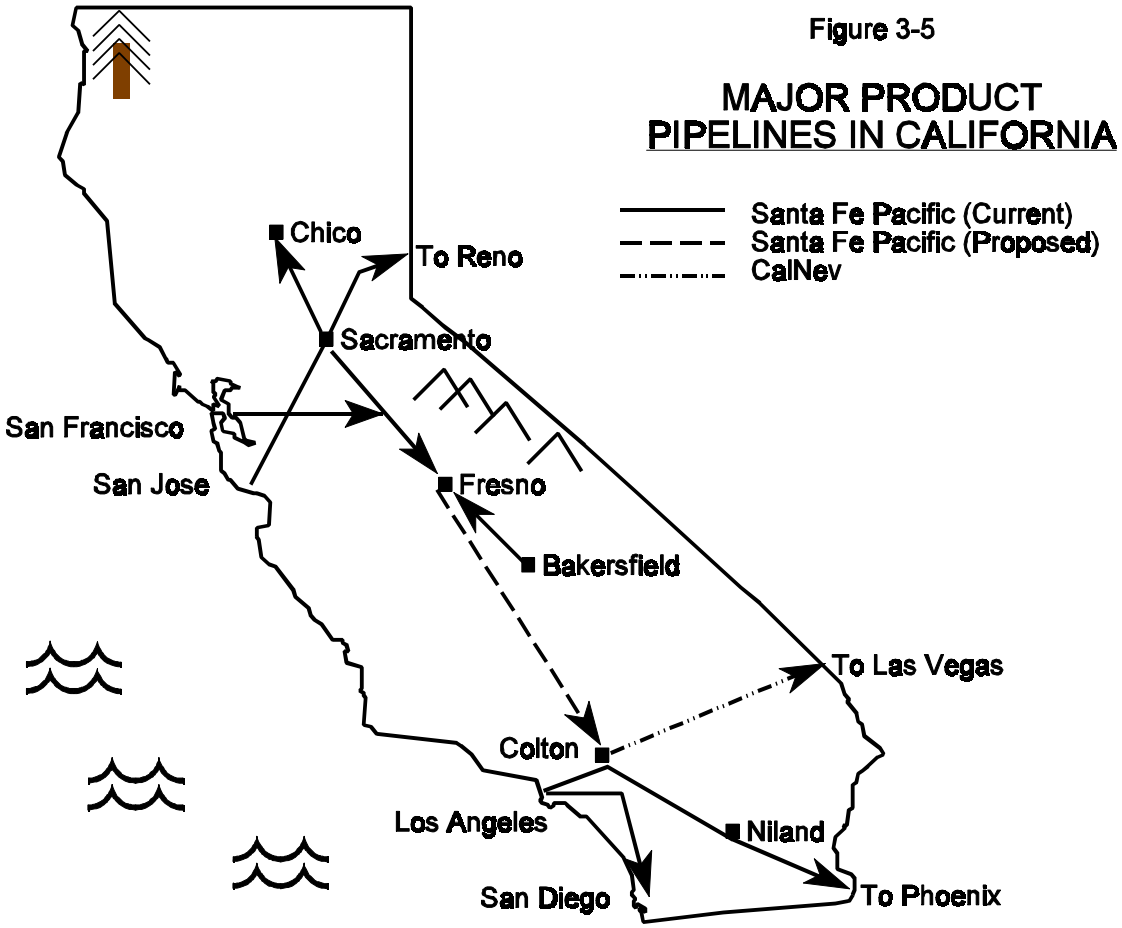


some terminals may not be able to accommodate all grades for all companies. Pipeline operations are a complex, 24-hours a day system not only because of the numerous product grades to be transported, but also because of revisions in delivery schedules at the various locations. Although the pipeline company's shipping forecasters prepare monthly delivery schedules for each customer, changes are normally accepted up to seven days prior to pumping. In an emergency, when a refiner is unable to deliver the expected volume of product into the pipeline, last minute changes will be accepted to assist the shipper. A potential bottleneck with the transition to CARB Phase 2 RFG is the limited ability of the pipeline companies to handle product which does not meet specifications and must be segregated from other product which does meet the standard.

Santa Fe Pacific Pipeline Company is proposing a new petroleum product pipeline in California (see Figure 3-5). This proposed line would connect the terminus at Fresno south to their Colton facility in San Bernardino County. This project would effectively link Northern and Southern California, providing an economical alternative to transport product from Northern California refineries to markets in Southern California, Las Vegas and Phoenix. This situation could reduce the volume of product tankered or barged from north to south. As of the time of this report, the project is still in the engineering stage and will proceed to construction only if throughput demand warrants.

The use of tanker and barge transportation raises concerns about spills and accompanying environmental impacts. The Energy Commission has

Figure 3-5



examined the possibility that transition to CARB Phase 2 RFG may increase the volume of imported crude, product or blendstocks arriving in California by water. In 1992 a total of 3,887 tanker and barge trips were made into and out of California ports, 96 percent of which were made in the San Francisco and Los Angeles/Long Beach harbors. An Energy Commission assessment of California port facilities indicates, however, that a small to moderate increase in tanker movement would not overburden existing port facilities.

The San Francisco Bay received 1,100 tankers in 1993, roughly 92 tankers monthly, transporting 18.5 million barrels of crude oil and 8 million barrels of petroleum products per month. The tanker traffic has remained relatively flat over the past few years. Tanker movement into the San Francisco Bay is complex, partly by the need for large crude oil tankers to be lightered because of the shallower draft in the Bay and at the berths. This procedure transfers crude oil to smaller vessels, resulting in additional cargo transfer and congestion because of the length of time tankers are in port. Tankers (and barges) usually move in and out of port within 36 to 72 hours, depending on pump rate and volume of cargo. In addition, tankers (those carrying a cargo of 5,000 long tons or greater) entering the San Francisco Bay are required to use tug escorts from one mile west of the Golden Gate as a collision prevention measure.

The side-by-side ports of Los Angeles and Long Beach receive about 50 percent of the state's tanker volume. In 1993, 946 tankers arrived at the ports of Los Angeles and Long Beach. Of these, about one-third were foreign vessels, and the remainder were United States flagships. Tanker traffic into the ports has remained fairly constant in the last several years. Officials at the ports of Los Angeles and Long Beach foresee no potential bottlenecks resulting from modest increases in tanker traffic. In fact, they are seeking to attract additional business, and have plans to expand their facilities over the next few decades. The berth owners and operators also feel confident that no major constraints exist at the port.

Table 3-1
PROPERTIES AND SPECIFICATIONS FOR CARB PHASE 2 RFG

Fuel Property	Units	Flat Limit	Average Limit	Cap Limit
Reid vapor pressure*	psi.	7	none	7
Sulfur	ppmw	40	30	80
Benzene*	vol. %	1	0.8	1.2
Aromatic hydrocarbons*	vol. %	25	22	30
Olefin	vol. %	6	4	10
Oxygen*	wt. %	1.8 - 2.2	none	1.8 - 2.7**
Temp. at 50% distilled (T50)	deg. F	210	200	220
Temp. at 90% distilled (T90)	deg. F	300	290	330

*Only these four requirements must be met by small refiners in 1996; the remaining four requirements must be met by March 1, 1998.
**There is no minimum requirement during the summertime for alternative formulations under the CARB predictive model. However, EPA does not allow the minimum to go below 1.8 percent in southern California and Sacramento (EPA Phase 1 RFG areas).

CALIFORNIA'S FUTURE CHALLENGES

Under the CARB Phase 2 RFG program, refiners may produce complying fuel, meeting the limits on eight fuel properties by one of four methods: flat limit, predictive model, averaging, or fleet test certification (see Table 3-1).

The predictive model is a mathematical equation designed to predict tailpipe emissions. If the calculated emissions reduction of a proposed alternative formulation, when compared to emissions from the Flat Limit or Averaging Limit formulas, is equivalent or better, then the formula can be submitted to the CARB for approval prior to production and shipment of the CARB RFG.

The CARB regulations also allow refiners the flexibility to average six of the eight fuel specifications over a 90-day period. If one component exceeds the averaging limit (but never exceeds the cap) in one batch, it can be offset by bringing the component under the averaging limit in a subsequent batch. CARB has amended this provision to include three 10-day extensions per year during the first two years of the program. While the averaging provision may provide some flexibility to refiners in meeting the RFG specifications, the predictive model may allow the refiners to take advantage of their individual refinery configuration differences.

Oxygenate Supply

CARB Phase 2 RFG is required to contain between 1.8 and 2.2 percent oxygen by weight. Under the CARB RFG predictive model, however, up to 2.7 percent by weight oxygen can be used. The regulations can be met by blending one of several types of oxygenates into the finished gasoline. Methyl tertiary butyl ether (MTBE) and ethanol are the two main oxygenates that refiners have used to meet the wintertime oxygenate requirement in California. Tertiary amyl methyl ether (TAME) and ethyl tertiary butyl ether (ETBE) are two additional oxygenates that will be either produced at certain California refineries or imported for use in the state. Some refineries currently have the ability to produce a certain amount of their required oxygenate on site, but this will permit the refiners to produce only approximately 15 percent of their own needs due to the limited availability of certain key feedstocks to create the oxygenates. The Energy Commission expects the remaining balance of the state's oxygenate needs to be imported from foreign and domestic sources.

Potential Marketing Concerns

The California petroleum fuel marketers are concerned about the need to separate different gasoline grades to ensure that the gasoline will remain in compliance with the regulations. The

question arises whether CARB RFG produced by one supplier can be mixed with that produced by another supplier and still be within the limit for all eight fuel specifications. This is a particular concern if fuel containing MTBE is mixed with fuel containing ethanol since the resulting mixture may violate the RVP standard. EPA prohibits the mixing of gasoline containing MTBE with gasoline containing ethanol in EPA RFG areas. In addition, various suppliers may blend in different additives. If these fuels have to be segregated, then more storage capacity will be required.

Marketers are also concerned about remaining in compliance while distributing product from different suppliers. While they want enforcement that is not unnecessarily burdensome, the industry recognizes that a monitoring system is needed to prevent the deliberate sale of non-complying fuel in California. Currently, where fungibility of a product is not a problem, the non-contract marketer can purchase products from the supplier with the lowest price, without being confined to California. For example, marketers in the extreme northern portion of California may currently choose to obtain fuel from either a terminal in southern Oregon or at the Chico pipeline terminal, whichever has the lower price. This business practice may change if certain out-of-state terminal operators decide not to carry CARB RFG.

Regional Refining and Fuel Specifications

The Energy Commission has reviewed the advantages and disadvantages of establishing common fuel specifications for the western states located in the Petroleum Administration Defense District V (PADD V): Arizona, California, Nevada, Oregon and Washington. (Alaska and Hawaii are also in PADD V but their products are supplied primarily by local refineries.) Western refineries produce gasoline and distillates (primarily diesel) for distribution in more than one state, complying with more than one set of fuel specifications.

The western states have three refining areas, each with its own distribution system: Los Angeles, San Francisco and the Puget Sound area of Washington. Refiners in Los Angeles supply Southern California, Phoenix and Southern Nevada. Refiners in San Francisco supply Northern California, Northern Nevada and Southern Oregon, where fuel is transported by truck from the Chico pipeline terminal. Refiners in Washington are the primary product suppliers to Oregon and Washington, with a small amount of both finished and unfinished products currently tankered to California. Within each area supplied by west coast refiners, different air quality conditions exist.

Even though all the western states use oxygenated gasoline, California's CARB diesel and Phase 2 RFG establish stricter specifications than the EPA Phase 1 gasoline and diesel used in the other states. One advantage of other states using the cleaner fuel is the air quality improvement to be gained even though the other states do not have the same severity of air quality problems. However, the use of RFG may not be the least cost program in other states where other less costly air pollution control measures have not yet been implemented.

The regional use of CARB Phase 2 RFG and diesel could improve economies of scale, reducing the per-unit capital costs of refining, as well as distribution and storage costs because of the reduced demand for segregated storage. Refinery modification for RFG may also increase the gasoline yield, although that amount cannot be confirmed until actual production begins March 1, 1996. The economies of scale advantage could have been realized if supplying regional demand had been included during the design phase. As it stands now, it may be expensive for most refineries to expand CARB RFG production to meet regional demand, requiring the construction or expansion of certain units, principally alkylation units.

ENDNOTES

1. Benzene and other aromatic hydrocarbons, such as toluene and xylene, are characterized by ring structures of carbon atoms. Aromatics are a factor in determining the temperature at which gasoline burns. Limiting aromatics content in gasoline will reduce the emission of volatile organic compounds (VOCs), Nox and toxics. RVP is a measure of a liquid's volatility, or tendency to evaporate, in pounds per square inch. In gasoline, lower RVP means less evaporation and, consequently, less emissions of VOCs.

2. Oil Price Information Service newsletter.

3. Joint ARB/CEC survey forms.

4. Information submitted by oil companies under the Petroleum Industry Information Reporting Act.